PB-240 203

LAKE CAROLOS, DOUGLAS COUNTY, MINNESOTA

Pacific Northwest Environmental Research Laboratory

Prepared for:

National Environmental Research Center
Minnesota Pollution Control Agency
Minnesota National Guard

November 1974

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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivded according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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REPORT

ON

LAKE CARLOS

DOUGLAS COUNTY

MINNESOTA

EPA REGION V

WORKING PAPER No. 91

WITH THE COOPERATION OF THE

MINNESOTA POLLUTION CONTROL AGENCY

AND THE

MINNESOTA NATIONAL GUARD

NOVEMBER, 1974

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Minnesota Pollution Control Agency for professional involvement and to the Minnesota National Guard for conducting the tributary sampling phase of the Survey.

Grant J. Merritt, Director of the Minnesota Pollution Control Agency, John F. McGuire, Chief, and Joel G. Schilling, Biologist, of the Section of Surface and Groundwater, Division of Water Quality, provided invaluable lake documentation and counsel during the course of the Survey; and the staff of the Section of Municipal Works, Division of Water Quality, were most helpful in identifying point sources and soliciting municipal participation in the Survey.

Major General Chester J. Moeglein, the Adjutant General of Minnesota, and Project Officer Major Adrian Beltrand, who directed the volunteer efforts of the Minnesota National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

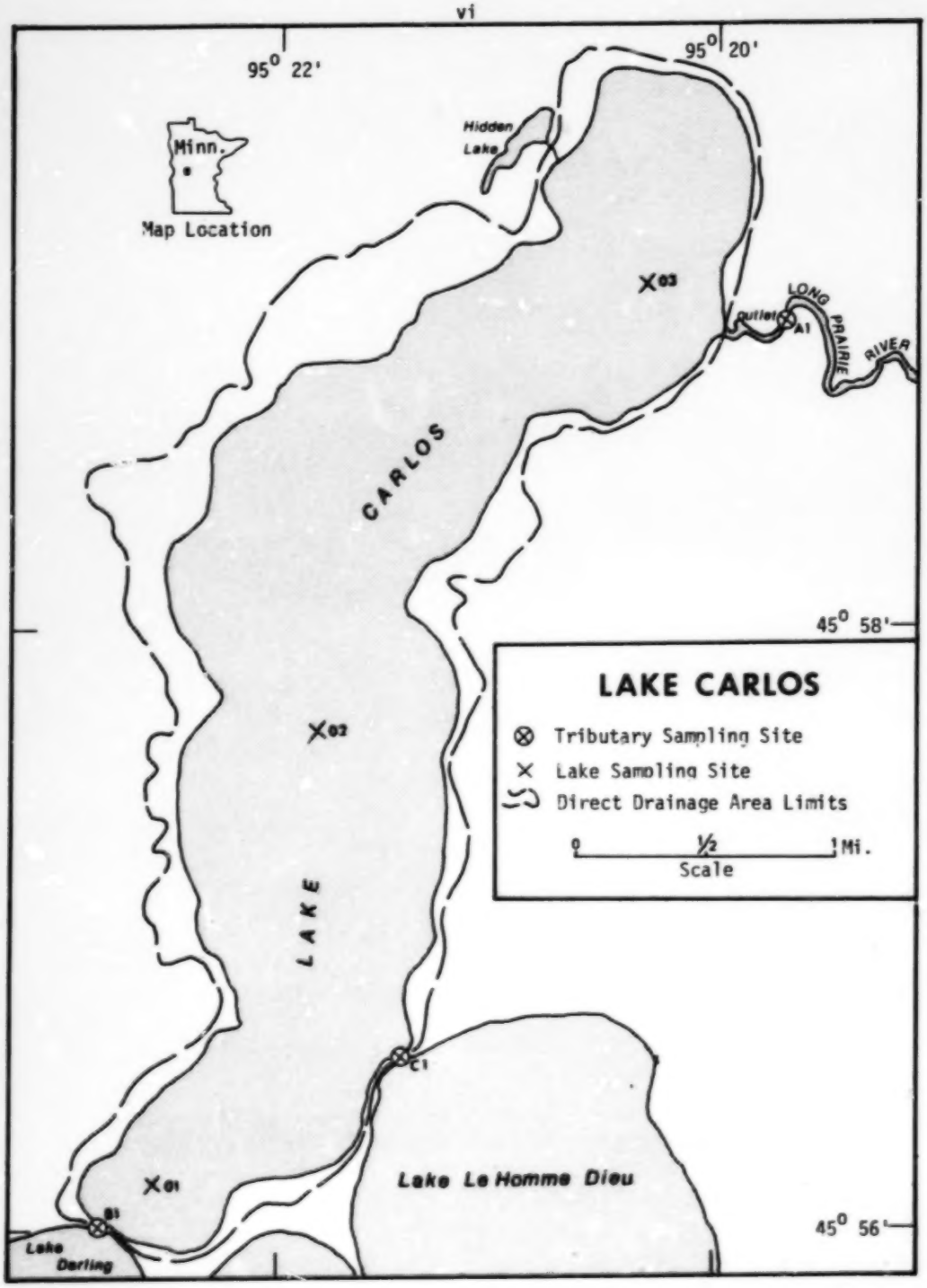
NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF MINNESOTA

LAKE NAME	COUNTY
Albert Lea	Freeborn
Andrusia	Beltrami
Badger	Polk
Bartlett	Koochiching
Bear	Freeborn
Bemidji	Beltrami
Big	Stearns
Big Stone	Big Stone, MN; Roberts, Grant, SD
Birch	Cass
Blackduck	Beltrami
Blackhoof	Crow Wing
Budd	Martin
Buffalo	Wright
Calhoun	Hennepin
Carlos	Douglas
Carrigan	Wright
Cass	Beltrami, Cass
Clearwater	Wright, Stearns
Cokato	Wright
Cranberry	Crow Wing
Darling	Douglas
Elbow	St. Louis
Embarass	St. Louis
Fall	Lake
Forest	Washington
Green	Kandiyohi
Gull	Cass
Heron	Jackson
Leech	Cass
Le Homme Dieu	Douglas
Lily	Blue Earth
Little	Grant
Lost	St. Louis

LAKE NAME	COUNTY
Madison	Blue Earth
Malmedal	Pope
Mashkenode	St. Louis
McQuade	St. Louis
Minnetonka	Hennepin
Minnewaska	Pope
Mud	Itasca
Nest	Kandiyohi
Pelican	St. Louis
Pepin	Goodhue, Wabasha, MN; Pierce, Pepin, WI
Rabbit	Crow Wing
Sakatah	Le Sueur
Shagawa	St. Louis
Silver	McLeod
Six Mile	St. Louis
Spring	Washington, Dakota
St. Croix	Washington, MN; St. Croix, Pierce, WI
St. Louis Bay	St. Louis, MN; Douglas, WI
Superior Bay	St. Louis, MN; Douglas, WI
Swan	Itasca
Trace	Todd
Trout	Itasca
Wagonga	Kandiyohi
Wallmark	Chisago
White Bear	Washington
Winona	Douglas
Wolf	Beltrami, Hubbard
Woodcock	Kandiyohi
Zumbro	Olmstead, Wabasha


95° 22'
95° 20'
Minn.
Map Location
Hidden Lake
03
Outlet
A1
LONG PRAIRIE RIVER
CARLOS
45° 58'
LAKE CARLOS
Tributary Sampling Site
Lake Sampling Site
Direct Drainage Area Limits
0
½
1 Mi.
Scale
02
LAKE
C1
Lake Le Homme Dieu
01
B1
Lake Darling
45° 56'

LAKE CARLOS

STORET NO. 27B9

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate Lake Carlos is mesotrophic. Of the 60 Minnesota lakes sampled in the fall when essentially all were well-mixed, none had less mean total and dissolved phosphorus, and 15 had less mean inorganic nitrogen. For all 80 lakes studied, only 6% had less mean chlorophyll a, and 7% had greater mean Secchi disc transparency.

Some depression of dissolved oxygen with depth was noted at stations 2 and 3 in September, 1972.

B. Rate-Limiting Nutrient:

The results of the algal assay show that Lake Carlos was phosphorus limited at the time the assay sample was collected. The lake data indicate phosphorus limitation at the other sampling times as well.

C. Nutrient Controllability:

1. Point sources--The elimination of the Alexandria Main plant discharge to Upper Lake Winona* should result in some reduction of the present oligotrophic loading rate to Lake Carlos (see page 13).

* See "Report on Lake Winona", Working Paper No. 135.

2. Non-point sources (see page 13)--The non-point phosphorus exports to Lake Carlos were exceptionally low because of nutrient entrapment in the water bodies tributary to Lake Carlos.

In all, non-point sources are estimated to have contributed nearly 65% of the total phosphorus load to the lake during the sampling year.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS

A. Lake Morphometry†

1. Surface area: 2,520 acres.
2. Mean depth: 43 feet.
3. Maximum depth: 163 feet.
4. Volume: 108,360 acre/feet.
5. Mean hydraulic retention time: 3.7 years.

B. Tributary and Outlet:
(See Appendix A for flow data)

1. Tributaries -

Name	Drainage area*	Mean flow*
Lake Darling outlet	175.0 mi^2	30.7 cfs
Le Homme Dieu Lake outlet	42.3 mi^2	7.2 cfs
Minor tributaries & immediate drainage -	12.8 mi^2	2.4 cfs
Totals	230.1 mi^2	40.3 cfs

2. Outlet -

Long Prairie River	234.0 mi^2**	40.3 cfs

C. Precipitation***:

1. Year of sampling: 22.9 inches.
2. Mean annual: 22.6 inches.

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† DNR lake survey map (1960); mean depth by random-dot method.
* Drainage areas are accurate within ±5%; mean daily flows are accurate within ±10%; and ungaged flows are accurate within ±10 to 25% for drainage areas greater then 10 mi^2.
** Includes area of lake.
*** See Working Paper No. 1, "Survey Methods".

III. LAKE WATER QUALITY SUMMARY

Lake Carlos was sampled three times during the open-water season of 1972 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from three stations on the lake and from a number of depths at each station (see map, page vi). During each visit, a single depth-integrated (15 feet to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the last visit, a single five-gallon depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 42 feet at station 1, 102 feet at station 2, and 50 feet at station 3.

The results obtained are presented in full in Appendix B, and the data for the fall sampling period, when the lake was essentially well-mixed, are summarized below. Note, however, the Secchi disc summary is based on all values.

For differences in the various parameters at the other sampling times, refer to Appendix B.

A. Physical and chemical characteristics:

Parameter	Minimum	Mean	Median	Maximum
		FALL VALUES (10/28/72)		
Temperature (Cent.)	7.3	7.5	7.6	7.7
Dissolved oxygen (mg/l)	8.4	9.6	9.7	10.6
Conductivity (μmhos)	320	331	330	340
pH (units)	8.0	8.0	8.0	8.1
Alkalinity (mg/l)	187	191	191	193
Total P (mg/l)	0.010	0.013	0.013	0.018
Dissolved P (mg/l)	0.006	0.007	0.007	0.009
$NO_2 + NO_3$ (mg/l)	0.050	0.067	0.070	0.080
Ammonia (mg/l)	0.040	0.057	0.060	0.070
		ALL VALUES		
Secchi disc (inches)	72	112	118	144

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera		Number per ml
07/10/72	1.	Dinobryon	3,201
	2.	Flagellates	452
	3.	Microcystis	434
	4.	Anabaena	235
	5.	Chroococcus	199
		Other genera	795
		Total	5,316
09/02/72	1.	Microcystis	3,986
	2.	Kirchneriella	3,080
	3.	Merismopedia	1,413
	4.	Dinobryon	616
	5.	Anabaena	507
		Other genera	2,463
		Total	12,065
10/28/72	1.	Chroococcus	1,558
	2.	Flagellates	1,306
	3.	Dinobryon	904
	4.	Lyngbya	628
	5.	Synedra	176
		Other genera	1,106
		Total	5,678

2. Chlorophyll a -
(Because of instrumentation problems during the 1972 sampling, the following values may be in error by plus or minus 20 percent.)

Sampling Date	Station Number	Chlorophyll a (μg/l)
07/10/72	01	6.4
	02	4.2
	03	3.2
09/02/72	01	4.2
	02	5.2
	03	4.3
10/28/72	01	5.3
	02	3.5
	03	5.4

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.012	0.117	0.9
0.005 P	0.017	0.117	2.5
0.010 P	0.022	0.117	2.7
0.020 P	0.032	0.117	2.8
0.050 P	0.062	0.117	2.8
0.050 P + 10.0 N	0.062	10.117	24.8
10.0 N	0.012	10.117	0.5

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Lake Carlos was relatively low at the time the sample was collected. Also, the increase in yield with increasing increments of orthophosphorus (to about 0.020 mg/l) shows that the lake was phosphorus limited. Note that the addition

of only nitrogen did not result in a yield significantly different than the control yield.

The lake data indicate phosphorus limitation at the other sampling times as well; i.e., N/P ratios were 17/1 or greater.

IV. NUTRIENT LOADINGS
(See Appendix C for all data)

For the determination of nutrient loadings, the Minnesota National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page vi), except for the high runoff months of April and May, when two samples were collected, and the colder months when two samples were omitted at station C-1 because of low flows. Sampling was begun in October, 1972, and was completed in September, 1973.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Minnesota District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of the U.S. Geological Survey computer program for calculating stream loadings. Nutrient loadings for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated by using the mean nutrient loads, in $lbs/mi^2/year$, in streams tributary to nearby Big Stone Lake at stations 2709D-1, E-1, F-1, and G-1 and multiplying the means by the Lake Carlos ZZ area in mi^2.

There are no known point sources impacting Lake Carlos directly. Lake Le Homme Dieu retained 80% of the P load and 6[illegible]% of the N load from the City of Alexandria Main Plant during the sampling year. In the

following loading tables, the nutrient loads attributed to the indirect point source were estimated on the basis of the Lake Le Homme Dieu retention, and the loads attributed to that outlet are those measured minus the point-source loads.

A. Waste Sources:

1. Known municipal (indirect only)* -

Name	Pop. Served	Treatment	Mean Flow (mgd)	Receiving Water
Alexandria Main	5,090	trickling filter	0.644	Upper Lake Winona

2. Known industrial - None

* See "Report on Lake Le Homme Dieu" (Working Paper No. 106).

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	lbs P/ yr	% of total
a. Tributaries (non-point load) -		
Lake Darling outlet	1,160	37.4
Le Homme Dieu outlet	220	7.1
b. Minor tributaries & immediate drainage (non-point load) -	240	7.7
c. Known municipal -		
Alexandria Main*	150	4.8
d. Septic tanks** -	940	30.3
e. Known industrial - None	-	-
f. Direct precipitation*** -	390	12.7
Total	3,100	100.0

2. Outputs -

Lake outlet - Long Prairie River 1,360

3. Net annual P accumulation - 1,740 pounds

* Indirect.
** Estimate based on 128 seasonal and 105 permanent dwellings and one park on shoreline; see Working Paper No. 1.
*** See Working Paper No. 1.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	lbs N/yr	% of total
a. Tributaries (non-point load) -		
Lake Darling outlet	72,600	48.4
Lake Le Homme Dieu outlet	16,910	11.3
b. Minor tributaries & immediate drainage (non-point load) -	4,720	3.2
c. Known municipal -		
Alexandria Main*	950	0.6
d. Septic tanks** -	30,400	20.3
e. Known industrial - None	-	-
f. Direct precipitation*** -	24,280	16.2
Total	149,860	100.0

2. Outputs -

Lake outlet - Long Prairie River 83,270

3. Net annual N accumulation - 66,590 pounds

* Indirect.
** Estimate based on 128 seasonal and 105 permanent dwellings and one park on shoreline; see Working Paper No. 1.
*** See Working Paper No. 1.

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	lbs $P/mi^2/yr$	lbs $N/mi^2/yr$
Lake Darling outlet	7	415
Lake Le Homme Dieu outlet	5	400

E. Yearly Loading Rates:

In the following table, the existing phosphorus loading rates are compared to those proposed by Vollenweider (in press). Essentially, his "dangerous" rate is the rate at which the receiving waters would become eutrophic or remain eutrophic; his "permissible" rate is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic rate would be considered one between "dangerous" and "permissible".

	Total Phosphorus		Total Nitrogen	
Units	Total	Accumulated	Total	Accumulated
lbs/acre/yr	1.2	0.7	59.5	26.4
grams/m^2/yr	0.14	0.08	6.7	3.0

Vollenweider loading rates for phosphorus ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Lake Carlos:

"Dangerous" (eutrophic rate)	0.36
"Permissible" (oligotrophic rate)	0.18

V. LITERATURE REVIEWED

Anonymous, 1969. Report on water quality investigation of the Long Prairie River and lakes Carlos, Le Homme Dieu and Osakis. MPCA, Minneapolis.

Bishop, Kyle M., and John F. McGuire, 1968(?). Report on pollution of lakes Winona, Agnes and Henry. MPCA, Minneapolis.

Schilling, Joel, 1974. Personal communication (lake map). MPCA, Minneapolis.

Vollenweider, Richard A., (in press). Input-output models. Schweiz. A. Hydrol.

VII. APPENDICES

APPENDIX A

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR MINNESOTA 10/30/74

LAKE CODE 27R9 CARLOS LAKE

TOTAL DRAINAGE AREA OF LAKE 234.00

NORMALIZED FLOWS

TRIBUTARY	SUB-DRAINAGE AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
27R9A1	234.00	4.40	10.20	30.00	112.00	68.50	76.70	45.90	32.30	16.70	40.90	34.20	11.60	40.32
27R9B1	175.00	3.47	7.45	23.20	85.10	53.30	59.40	33.90	24.20	12.90	30.80	25.40	4.76	30.72
27R9C1	42.30	0.52	1.03	5.12	21.10	12.70	15.50	8.48	5.09	3.09	6.53	5.00	1.63	7.16
27R9Z2	14.20	0.42	0.76	1.99	5.84	4.10	4.91	2.83	1.82	1.26	2.51	1.78	0.96	2.43

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 234.00 TOTAL FLOW IN = 483.25
SUM OF SUB-DRAINAGE AREAS = 231.50 TOTAL FLOW OUT = 483.50

NOTE *** TRIB B9B1=B4C1; B3C1=B5C1

MEAN MONTHLY FLOWS AND DAILY FLOWS

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
27R9A1	10	72	113.00	14	120.00				
	11	72	106.00	15	103.00				
	12	72	58.70	15	49.00				
	1	73	23.10	12	22.00				
	2	73	55.10	21	54.00				
	3	73	137.00	13	116.00				
	4	73	140.00	5	175.00	19	133.00		
	5	73	115.00	3	133.00	17	109.00		
	6	73	80.00	8	91.00				
	7	73	56.50	11	8.97				
	8	73	62.50	23	0.88				
	9	73	26.70	30	0.82				
27R9B1	10	72	83.80	14	90.00				
	11	72	76.80	15	74.00				
	12	72	37.80	15	36.00				
	1	73	16.90						
	2	73	39.50	21	39.00				
	3	73	104.00	13	88.00				
	4	73	124.00	5	130.00	19	98.80		
	5	73	87.90	3	102.00	17	84.00		
	6	73	61.00	8	70.00				
	7	73	41.00	11	39.70				
	8	73	46.00	23	40.50				
	9	73	20.30	30	16.60				

TRIBUTARY FLOW INFORMATION FOR MINNESOTA 10/30/74

LAKE CODE 2749 CARLOS LAKE

MEAN MONTHLY FLOWS AND DAILY FLOWS

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
278901	10	72	17.80	14	19.00				
	11	72	15.10	15	15.00				
	12	72	7.01	15	6.70				
	1	73	2.54						
	2	73	5.46	21	2.50				
	3	73	23.00	13	20.00				
	4	73	25.70	5	32.00	19	24.00		
	5	73	21.00	3	24.00	17	20.00		
	6	73	15.80	8	18.00				
	7	73	10.30	11	9.95				
	8	73	9.67	23	8.51				
	9	73	4.85	30	3.98				
278977	10	72	6.83	14	7.30				
	11	72	5.39	15	5.20				
	12	72	4.12	15	4.00				
	1	73	2.05	12	2.00				
	2	73	4.03	21	4.00				
	3	73	8.96	13	7.60				
	4	73	7.12	5	8.90	19	6.80		
	5	73	6.76	3	7.80	17	6.40		
	6	73	5.01	8	5.70				
	7	73	3.42	11	3.32				
	8	73	3.45	23	3.04				
	9	73	1.98	30	1.62				

APPENDIX B

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 74/10/30

278901
45 56 06.0 095 22 35.0
LAKE CARLOS
27 MINNESOTA

11EPALES 2111202
3 0036 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/07/10	09 20	0000	21.1		120	380	8.50	197	0.050	0.070	0.012	0.008
	09 20	0004	21.5	9.2		370	8.50	193	0.080	0.080	0.013	0.007
	09 20	0015	17.0	9.6		380	8.50	192	0.080	0.080	0.013	0.009
	09 20	0032	17.1	8.0		390	8.00	197	0.070	0.070	0.015	0.008
72/09/02	09 15	0000	17.2		84	345	8.50	170	0.120	0.160	0.020	0.014
	09 15	0004	19.4	9.0		340	8.50	190	0.120	0.130	0.010	0.010
	09 15	0015	19.4	8.7		420	8.55	185	0.130	0.160	0.019	0.014
	09 15	0022	19.3	8.6		355	8.53	185	0.130	0.160	0.015	0.010
	09 15	0029	18.8	7.2		355	8.32	188	0.140	0.180	0.018	0.014
72/10/28	12 45	0000			124	330	8.00	191	0.070	0.060	0.018	0.006
	12 45	0004	7.5	10.0		330	8.00	192	0.070	0.040	0.013	0.006
	12 45	0015	7.5	9.2		330	8.00	192	0.070	0.060	0.013	0.006
	12 45	0025	7.5	8.4		330	8.00	190	0.070	0.060	0.013	0.006
	12 45	0042	7.3	9.8		340	8.00	190	0.080	0.060	0.015	0.007

19

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/07/10	09 20	0000	6.4J
72/09/02	09 15	0000	4.2J
72/10/28	12 45	0000	5.3J

J VALUE KNOWN TO BE IN ERROR

STORET RETRIEVAL DATE 74/10/30

278902
45 57 37.0 095 21 52.0
LAKE CARLOS
27 MINNESOTA

11EPALES 2111202
3 0050 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/07/10	12 45	0000	23.0		115	370	8.60	196	0.110	0.130	0.013	0.011
	12 45	0004	22.2	9.2		380	8.60	197	0.080	0.080	0.011	0.007
	12 45	0015	20.4	8.4		380	8.50	193	0.010	0.050	0.013	0.007
	12 45	0025	15.4	8.2		380	8.30	198	0.050	0.050	0.014	0.008
	12 45	0046	16.2	7.0		380	7.70	198	0.050	0.050	0.015	0.009
72/09/02	09 55	0000			72	340	8.58	173	0.110	0.140	0.017	0.010
	09 55	0004	19.5	9.4		335	8.58	170	0.100	0.140	0.016	0.008
	09 55	0015	19.4	9.1		330	8.60	176	0.090	0.100	0.009	0.007
	09 55	0022	19.3	9.1		325	8.58	172	0.130	0.130	0.014	0.008
	09 55	0030	18.5	7.4		320	8.45	177	0.100	0.130	0.014	0.008
	09 55	0045	11.2	3.0		365	7.65	189	0.100	0.110	0.012	0.007
	09 55	0060	8.8	2.8		365	7.60	189	0.120	0.100	0.010	0.011
	09 55	0075	6.3	3.7		360	7.60	189	0.250	0.120	0.011	0.007
	09 55	0090	5.9	3.9		360	7.60	189	0.270	0.130	0.014	0.008
	09 55	0102	5.5	2.0		370	7.50	187	0.330	0.180	0.046	0.017
72/10/28	13 15	0000			120	325	8.00	193	0.080	0.070	0.011	0.008
	13 15	0004	7.7	9.6		320	8.00	192	0.070	0.060	0.013	0.007
	13 15	0015	7.6	9.2		330	8.00	193	0.060	0.050	0.013	0.007
	13 15	0030	7.6	8.8		330	8.00	192	0.070	0.060	0.012	0.007
	13 15	0045	7.5	8.4		320	8.00	191	0.060	0.050	0.012	0.006

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/07/10	12 45	0000	4.2J
72/09/02	09 55	0000	5.2J
72/10/28	13 15	0000	3.5J

J VALUE KNOWN TO BE IN ERROR

STORET RETRIEVAL DATE 74/10/30

27H903
45 59 06.0 095 20 20.0
LAKE CARLOS
27 MINNESOTA

11EPALES 2111202
3 0054 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/07/10	12 15	0000	23.7		115	380	8.60	195	0.090	0.100	0.016	0.010
	12 15	0004	22.7	9.4		370	8.60	195	0.080	0.090	0.009	0.010
	12 15	0015	20.7			380	8.60	199	0.040	0.040	0.012	0.009
	12 15	0025	16.2	8.6		390	8.40	199	0.080	0.080	0.016	0.008
	12 15	0050	14.1	5.4		390	7.70	170	0.060	0.050	0.015	0.008
72/09/02	10 50	0000				340	8.60	162	0.120	0.130	0.017	0.010
	10 50	0004	19.9	8.5		330	8.60	161	0.120	0.130	0.013	0.009
	10 50	0015	19.5	7.9		370	8.50	169	0.100	0.140	0.013	0.010
	10 50	0022	18.4	7.1		340	8.45	174	0.100	0.150	0.014	0.010
	10 50	0028	18.5	6.2		330	8.35	177	0.120	0.170	0.013	0.010
	10 50	0035	14.6	2.3		375	7.73	188	0.100	0.150	0.015	0.008
	10 50	0045	11.6	2.6		370	7.60	193	0.110	0.130	0.014	0.009
72/10/28	13 45	0000			144	330	8.10	187	0.070	0.060	0.012	0.007
	13 45	0004	7.6	9.8		340	8.10	188	0.070	0.070	0.012	0.009
	13 45	0015	7.6	10.6		330	8.10	189	0.060	0.050	0.012	0.006
	13 45	0030	7.6	10.5		340	8.10	190	0.060	0.050	0.013	0.006
	13 45	0050	7.6	10.6		340	8.10	192	0.050	0.060	0.010	0.007

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/07/10	12 15	0000	3.2J
72/09/02	10 50	0000	4.3J
72/10/28	13 45	0000	5.4J

J VALUE KNOWN TO BE IN ERROR

APPENDIX C

TRIBUTARY DATA

STORET RETRIEVAL DATE- 74/10/30

2789A1 LS2789A1
45 56 00.0 095 23 00.0
LONG PRAIRIE
27 7.5 ALEXANDRIA E
O/LAKE CARLOS
BRDG 1.75 MI NW OF TOWN OF CARLOS
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/14	11 00		0.063	0.780	0.058	0.005K	0.021
72/12/15	11 40		0.043	0.710	0.017	0.005K	0.012
73/01/12	14 30		0.065	0.750	0.061	0.005K	0.015
73/02/21	11 45		0.075	0.580	0.063	0.005K	0.025
73/03/13	15 00		0.048	0.720	0.066	0.009	0.020
73/04/05	14 45		0.030	1.400	0.022	0.005K	0.015
73/04/19	15 05		0.034	0.420	0.019	0.005K	0.015
73/05/03	15 00		0.043	0.600	0.011	0.005K	0.010
73/05/17	15 20		0.010K	0.690	0.007	0.005K	0.020
73/06/08	11 25		0.010K	2.050	0.061	0.005K	0.015
73/07/11	15 00		0.010K	0.810	0.042	0.010	0.015
73/08/23			0.012	1.400	0.021	0.009	0.010
73/09/30	14 00		0.010K	0.940	0.052	0.008	0.020

K VALUE KNOWN TO BE LESS
THAN INDICATED

STORET RETRIEVAL DATE 74/10/10

27H9H1 27H4C1
45 56 00.0 095 23 00.0
LK CARLOS/LK DARLING CONNECTION
27 7.5 ALEXANDRIA W
I/LAKE CARLOS
CO RD BRDG 2 MI N OF ALEXANDRIA
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/14	10	40	0.120	1.000	0.130	0.005K	0.024
72/11/15	15	30	0.100	0.900	0.079	0.012	0.024
72/12/15	10	30	0.115	1.100	0.048	0.005K	0.014
73/01/12	14	35	0.138	1.050	0.060	0.005K	0.020
73/02/21	10	30	0.220	0.880	0.038	0.005K	0.025
73/03/13	15	15	0.256	0.870	0.052	0.005K	0.015
73/04/05	14	00	0.170	1.540	0.058	0.005K	0.020
73/04/19	14	15	0.130	1.430	0.037	0.005K	0.020
73/05/03	14	40	0.048	0.790	0.013	0.005K	0.015
73/05/17	14	55	0.012	0.905	0.028	0.006	0.015
73/06/08	11	05	0.340	0.730	0.016	0.005K	0.020
73/07/11	14	10	0.010K	2.900	0.031	0.007	0.015
73/08/23			0.021	0.850	0.014	0.005K	0.015
73/09/30	14	25	0.010K	1.000	0.044	0.013	0.015

K VALUE KNOWN TO BE LESS
THAN INDICATED

24

STORET RETRIEVAL DATE 74/10/30

2789C1 2785C1
45 56 30.0 095 21 30.0
LK CARLOS/LK LE HOMME DIEU CONN
27 7.5 ALEXANDRIA E
I/LAKE CARLOS
CO HWY 29 BRDG 3.5 MI NNE OF ALEXANDRIA
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/14	11	00	0.031	1.540	0.120	0.029	0.063
72/11/15	15	30	0.085	0.950	0.120	0.012	0.028
73/02/21	11	00	0.150	0.850	0.034	0.005K	0.020
73/04/05	14	45	0.053	1.150	0.018	0.005K	0.015
73/04/19	14	25	0.062	2.600	0.060	0.005K	0.025
73/05/03	14	50	0.046	0.660	0.007	0.005	0.015
73/05/17	15	05	0.019K	0.990	0.005K	0.008	0.030
73/06/08	11	10	0.280	0.540	0.013	0.005K	0.020
73/07/11	14	20	0.010K	2.300	0.030	0.007	0.015
73/08/23			0.012	0.300	0.027	0.010	0.020
73/09/30	14	35	0.010K	0.840	0.028	0.006	0.025

K VALUE KNOWN TO BE LESS
THAN INDICATED